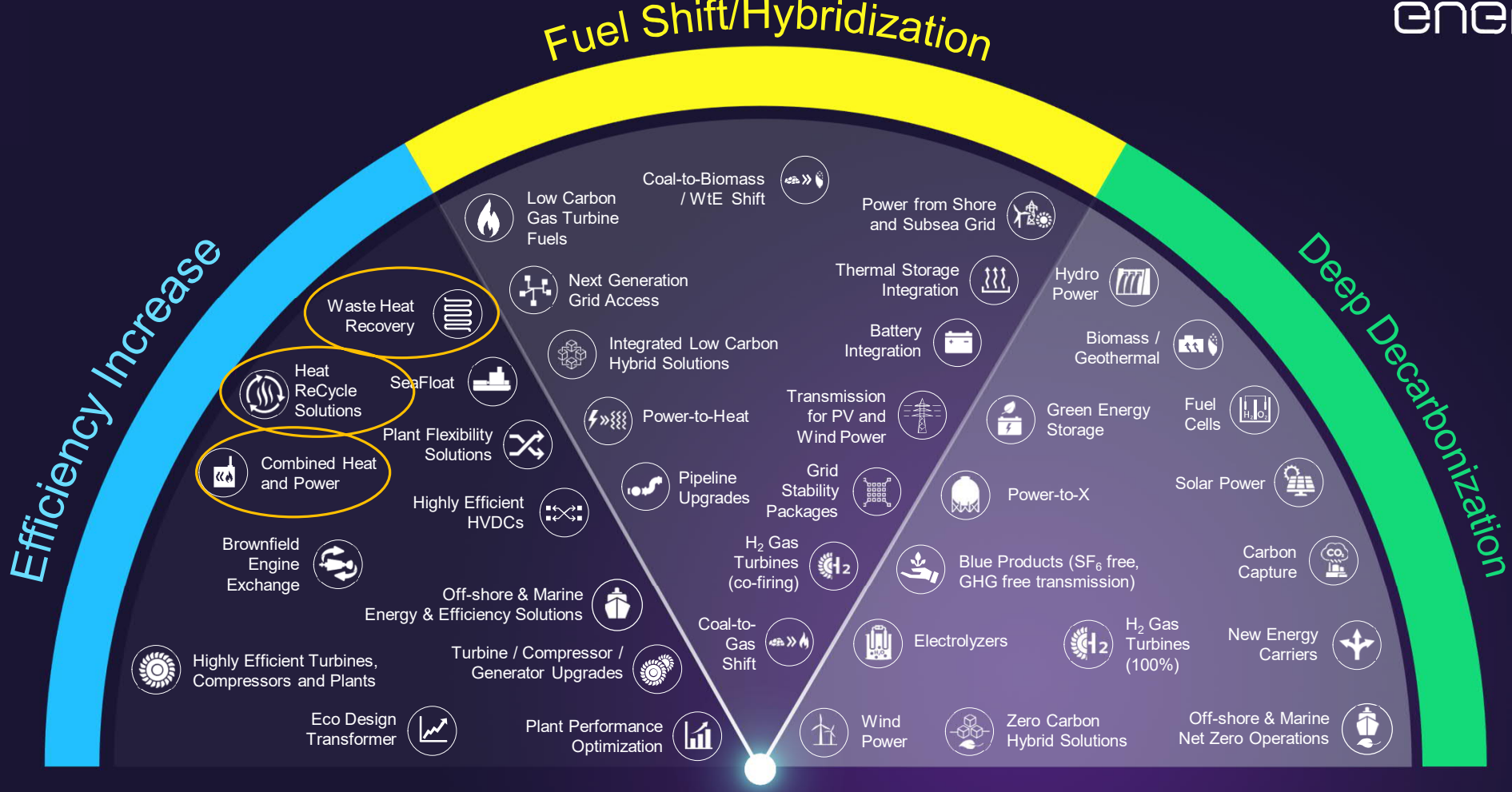
Too Good to Waste

Customer Event Steam Turbine and Generators 2023

Agenda

1. The Energy Trilemma
2. Heat Recovery Technologies
3. Applications & Solutions
4. Contact us

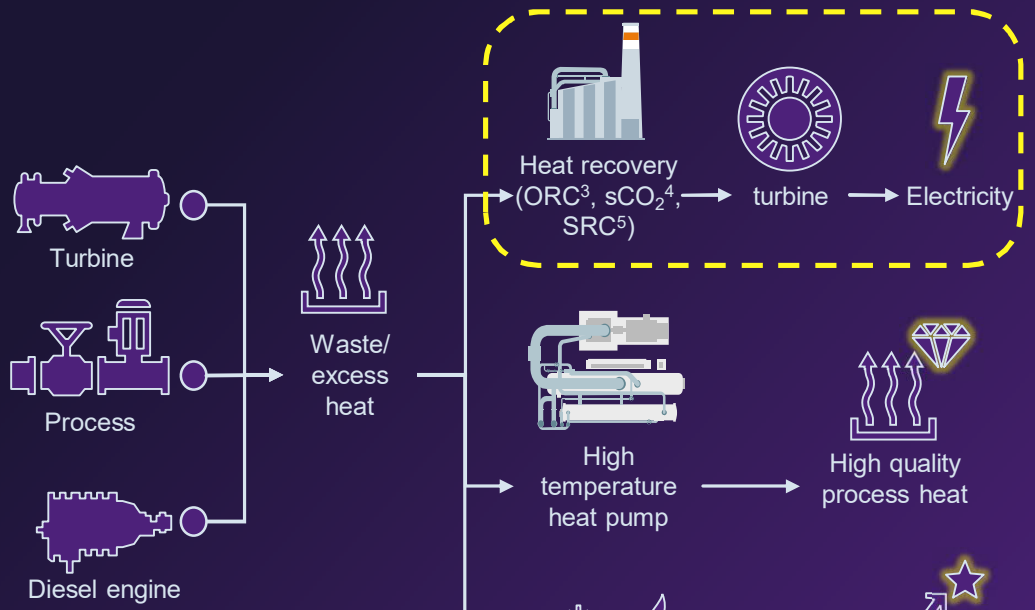
Decarbonization Radar



Heat utilization

Power and heat generation without incremental emissions

Power and quality heat from all kinds of waste heat in process industry



[1] HRSG – Heat Recovery Steam Generator
[2] WHRU – Waste Heat Recovery Unit
[3] ORC – Organic Rankine Cycle
[4] sCO_2 – Supercritical carbon dioxide
[5] SRC – Steam Rankine Cycle

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Decarbonization impact

- Captive generation to reduce electric power requirement in times of rising energy cost
- Decrease emissions in order to comply to stricter regulations and increased emission costing
- Energy Generation as additional value stream without additional CO_2 - , CO-, NO_x - or SO_x emissions

More customer benefits

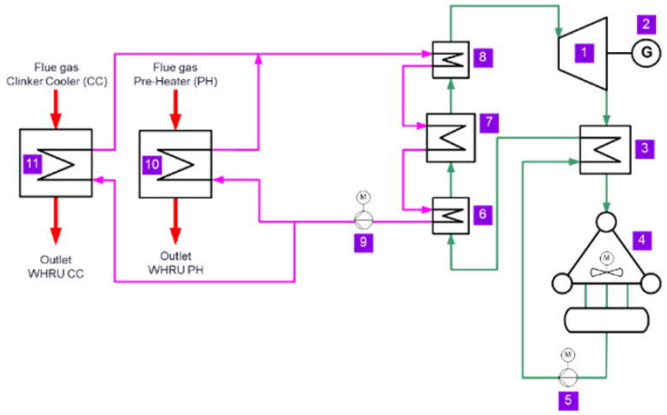
- OPEX reduction through monetization of waste heat
- Flexible, reliable and highly efficient power and heat supply
- High power density and small footprint enables smooth brownfield integration and minimized cost of land for greenfield
- Builds on robust and well proven standard building blocks for installation in any location including offshore platform
- Optimized space and weight solution
- Highly automated solutions w/o requirement for dedicated site personnel

Waste Heat Recovery Technologies

Different technologies exist to convert waste heat into electricity..

ORC WHR flow sheet

ACC solution shown

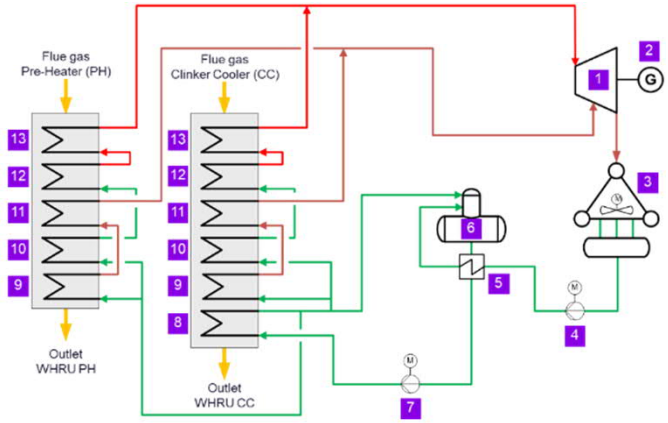


1	ORC turbine	2	Generator
3	Recuperator	4	Air cooled condenser
5	Feed pump	6	Pre-heater
7	Evaporator	8	Super-heater
9	Thermal oil pump	10	WHRU PH
11	WHRU CC		

ORC: Organic Rankine Cycle

Steam WHR flow sheet

ACC solution shown

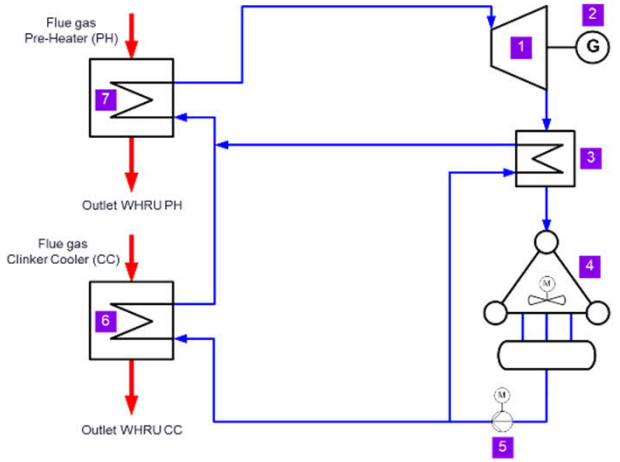


1	Steam turbine	2	Generator
3	Air cooled condenser	4	Condensate pump
5	Heat exchanger	6	Deaerator
7	Feedwater pump	8	Common economizer
9	LP evaporator	10	HP economizer
11	LP super-heater	12	HP evaporator
13	HP super-heater		

SRC: Steam Rankine Cycle

sCO2 WHR flow sheet

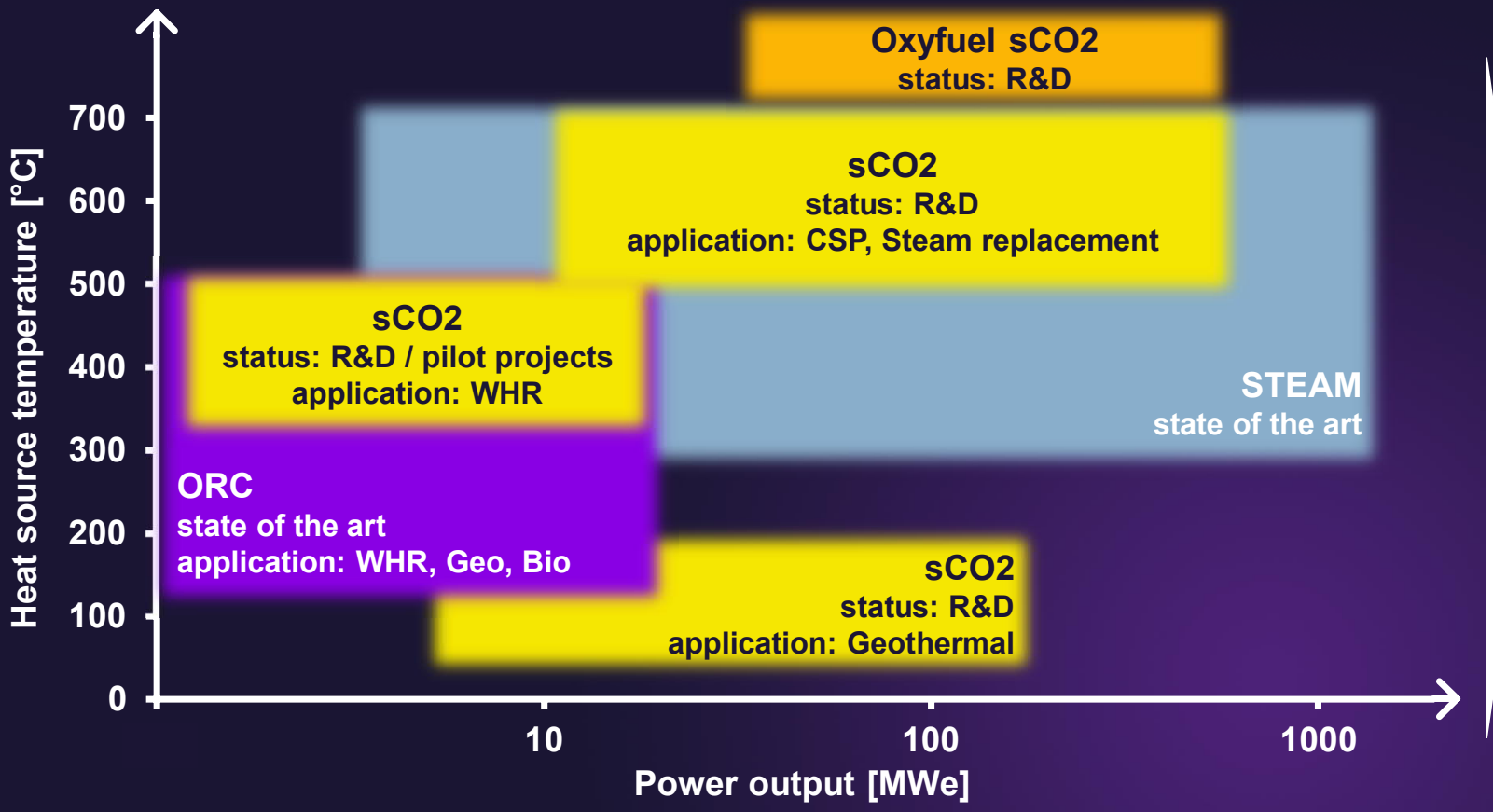
ACC solution shown



1	sCO2 turbine	2	Generator
3	Recuperator	4	Air cooled condenser
5	Compressor/ pump	6	WHRU CC
7	WHRU PH		

sCO2: Supercritical Carbon Dioxide Cycle

Different technologies exists to convert thermal heat into power…



- Different technologies exists to convert thermal heat into power:
  - Steam Rankine Cycle
  - Organic Rankine Cycle
  - Supercritical Carbon Dioxide Cycle
- **Currently Steam and ORC are fully commercialized**
- sCO2 is investigated

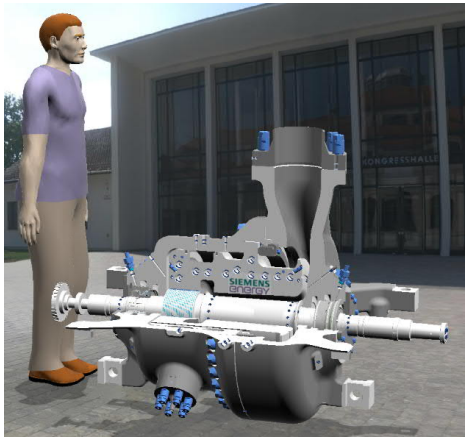
CSP: Concentrated Solar Power
WHR: Waste Heat Recovery
Geo: Geothermal
Bio: Biomass

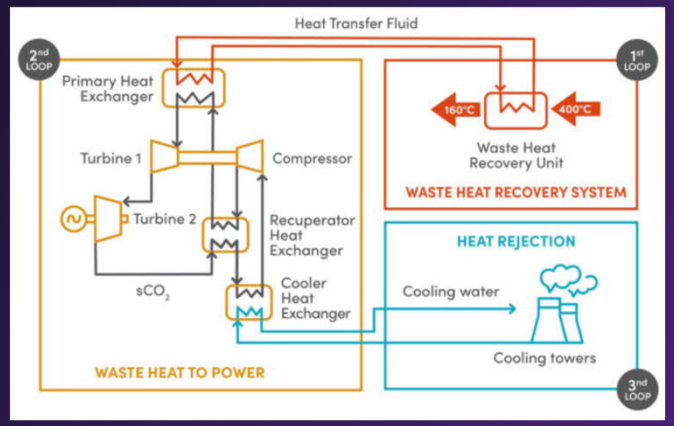
Large-Scale Industrial Waste Heat Recuperation with axial sCO_2 Turbine

Unit Scaling
2-100 MW

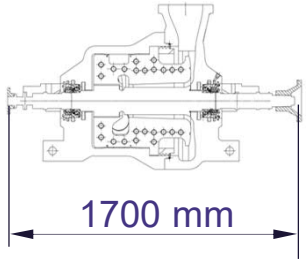
Turbine Performance
Up to 92%

- **Adapting barrel-type turbine design** for high temperatures and pressures, i.e. **high efficiencies**
- Realization and validation of **2 MW demo application** within EU funded project **CO2OLHEAT** *)
- Design **scalable to large power output** for different types of applications

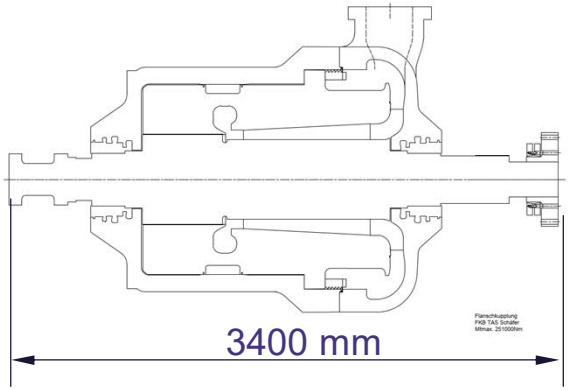




2 MW Demo sCO_2 turbine



Upscaled 50 MW sCO_2 turbine



*) This project has received funding from the European Union's Horizon 2020 research and innovation program under GA n. 101022831

Steam Turbines & Generators Portfolio

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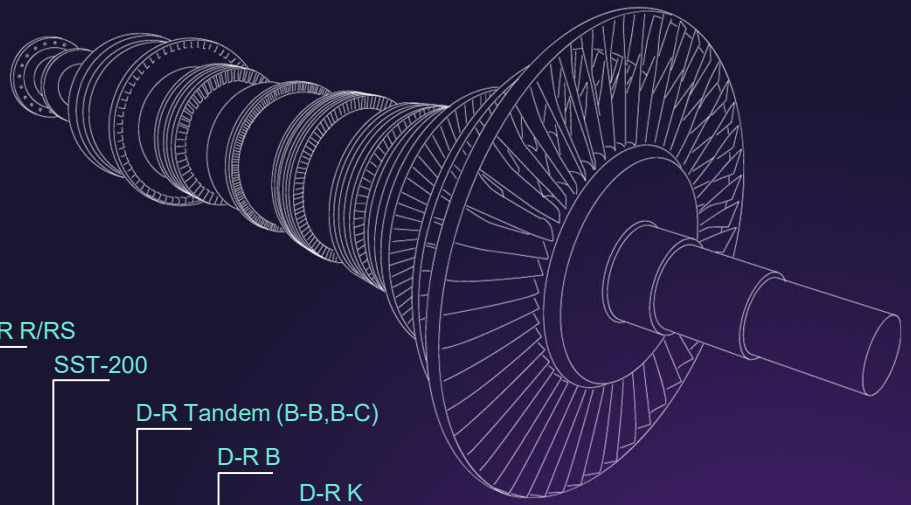
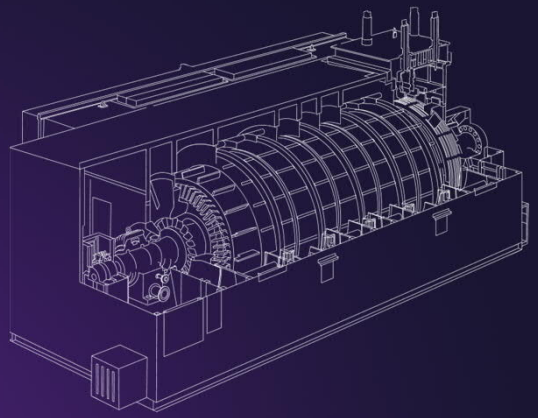
Steam Turbines *

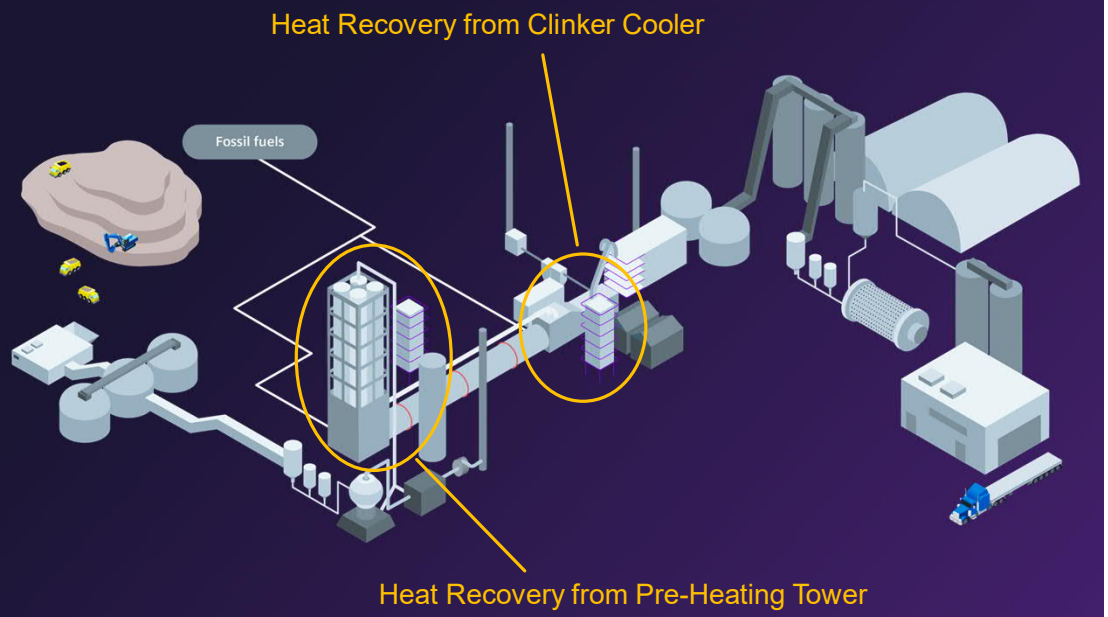


Generators



* incl. applications with alternative fluids (e.g. Air, CO_2 and Nitrogen)
incl. Gimpel® Valve portfolio

Cement – Waste Heat Recovery
Power and heat



Recover waste heat in order to generate captive power to satisfy about 30% of the plant's electricity requirement.

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Features

- Going beyond conventional electrification solution to make WHR most efficient and highly impactful towards decarbonization:
  - Highest possible system efficiency
  - Allows to accommodate process variations
  - Reduces the operating cost of applications such as CCU / CCS
- Heat recovery units:
  - HRSG[1], steam turbines and BoP for high temperatures
  - WHRU[2], turbines and BoP for medium temperatures
- Transfer media:
  - SRC – all ranges
  - ORC[3] for water-free and low temperature operations
- Highly automated solutions w/o requirement for dedicated site personnel

Sustainability impact

- Decreased fuel consumption
- Energy without additional CO_2 -, CO-, NO_x - or SO_x emissions

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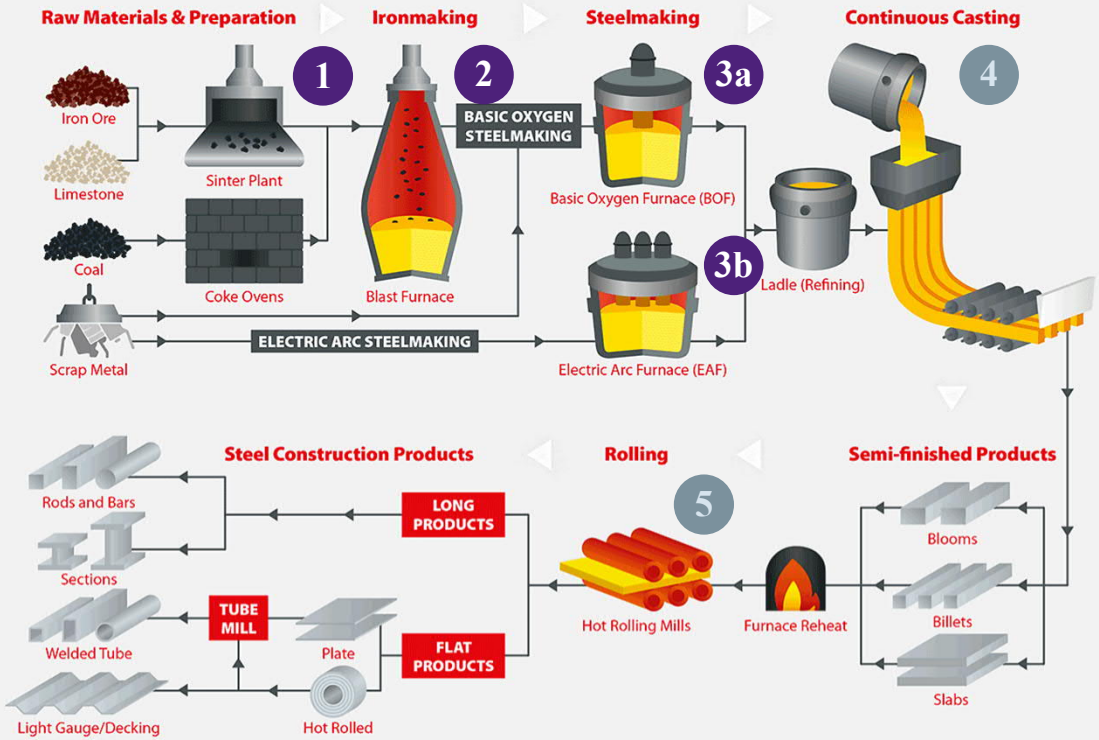
Steel – Waste Heat Recovery

Power and heat generation without incremental emissions



1) Sinter Plant
2) Blast Furnace
3a) Converter (Basic Oxygen Furnace
3b) Electric Arc Furnace
4) Continuous Casting Plant
5) Hot Rolling Mill

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Thermal Energy Storage

Utilization of available heat independently of the source (water, organic fluids, chemical fluids)

Features

- Different storage technologies can be included in Waste Heat Recovery Systems to utilize heat from discontinuous processes and/ or boost efficiency. The stored energy can be directly used or re-electrified via a water-steam cycle or an ORC
- Water/steam or oil can be used as heat transfer fluid. Direct connection to water-steam cycle is possible.
- < 425°C storage for medium temperature thermal storage. Main application is in industry
- Typical capacity range: 10 MWh_{th} – 1 GWh_{th}

Sustainability impact

- Increased energy efficiency of industrial processes
- Supporting the decarbonization through avoiding to waste heat and re-provide high quality process heat
- Electrification of industrial heat processes possible

Carbon Capture

Technology to capture CO_2 from power plant flue gases and industrial waste gases. Captured CO_2 may be reused as feed material for chemical syntheses (e.g. synthetic fuels), for geological storage & EOR, and as feedstock for chemical processes and products.

Decarbonization impact

- Reduce CO_2 emissions in flue gases by approx. 90%
- Technology suitable for new as well existing power plants and industrial plants
- Critical for hard to abate industries where carbon emissions are inherent to process such as for cement and steel

More customer benefits

- Lower costs (e.g. CO_2 taxation)
- Regional incentive programs for carbon capture utilization and storage
- Enhanced process integration into power plants
- Adjoining portfolio of equipment for CO_2 usage and storage solutions (e.g. waste heat utilization, compressors, integration and digital solutions)

GT-Tailing Applications

Decarbonization impact

- Efficiency up to 4 %pts higher than for comparable reciprocating internal combustion engine (RICE)
- Different Technologies available for bottoming cycle (SRC, ORC)
- Completely water-free / water sustainable solution if required
- Lower emissions and noise pollution compared to RICE
- Fuel flexibility

More customer benefits

- Very attractive CAPEX and OPEX
- Affordable electricity with the best LCoE
- Full remote and unmanned operation capability
- Excellent part load efficiency over wide range
- High reliability and availability with proven technology

Key Take Aways

Contact

Too Good to Waste

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